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**ДУАЛЬНА ОСВІТА
 ЯК ЗАСІБ ЗАБЕЗПЕЧЕННЯ НАЛЕЖНОЇ ЯКОСТІ
 ПРОФЕСІЙНОЇ ПІДГОТОВКИ
 ВЧИТЕЛІВ МАТЕМАТИКИ В СУЧАСНІЙ УКРАЇНІ**

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**DUAL EDUCATION
 AS A MEAN OF ENSURING PROPER QUALITY
 OF PROFESSIONAL TRAINING OF MATHEMATICS
 TEACHERS IN MODERN UKRAINE**

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АНОТАЦІЯ

Постановка проблеми. Якісна підготовка вчителів, зокрема, вчителів математики, завжди була і є першочерговим завданням педагогічного університету. Наразі в педагогічних університетах України підготовка магістрів відбувається традиційним шляхом, який передбачає читання лекцій, проведення практичних, лабораторних та семінарських занять, а також практику в школі. Однак, традиційна схема підготовки магістрів не завжди може бути належним чином забезпечена, оскільки значна частина студентів вимушена працювати в школі, а отже, не відвідує потрібну кількість лекцій та практичних занять, а практика в школі зводиться до «відпрацювання» її на робочому місці. Одним з ефективних шляхів вирішення вказаної проблеми є створення ефективної системи якісного поєднання теоретичної та практичної підготовки майбутніх вчителів з професійною діяльністю ще в період навчання в університеті.

Матеріали та методи. Для досягнення мети роботи ми використовуємо теоретичний метод аналізу методичної літератури з досліджуваного питання. Ми також використовуємо деякі емпіричні методи: опитування студентів щодо їх працевлаштування, спостереження за навчальним процесом підготовки вчителів у педагогічних університетах, аналіз навчальних досягнень майбутніх вчителів математики в сфері їх теоретичної та практичної підготовки. У цій статті ми також використовуємо комплекс методів наукового пізнання: порівняльний аналіз для з'ясування різних поглядів на проблему; систематизація та узагальнення з метою зробити висновки та сформулювати рекомендації щодо напрямків вдосконалення методики підготовки майбутніх вчителів математики; узагальнення педагогічного досвіду та спостережень авторів.

Результати. Усунути основні недоліки традиційних форм і методів навчання майбутніх фахівців, подолати розрив між

ABSTRACT

Formulation of the problem. Qualitative training of teachers, in particular, teachers of mathematics, has always been and is the primary task of a pedagogical university. Currently, in pedagogical universities of Ukraine, master's training takes place in the traditional way, which involves reading lectures, conducting practical, laboratory and seminar classes, as well as practice at school. However, the traditional master's training scheme cannot be adequately provided always, because a significant part of students forced to work at school, and therefore do not attend the required number of lectures and practical classes, and practice at school is reduced to "practicing" it at the workplace. One of the effective ways to solve this problem is to create an effective system of qualitative combination of theoretical and practical training of future teachers with professional activities even during their studies at the university.

Materials and methods. To achieve the goal of the work, we use the theoretical method of analyzing methodological literature on the researched problem. We also use some empirical methods: surveying students regarding their employment, observing the educational process of teacher training in pedagogical universities, analyzing the educational achievements of future mathematics teachers in the field of their theoretical and practical training. In this article, we also use a set of methods of scientific knowledge: comparative analysis to clarify different views on the problem; systematization and generalization in order to draw conclusions and formulate recommendations regarding directions for improving the methodology of training future mathematics teachers; summarizing the pedagogical experience and observations of the authors.

Results. To reduce the main shortcomings of the traditional forms and methods of training future specialists, to overcome the gap between the teacher training program at the university and the current requirements of school practice, and to increase the quality indicators of the training of qualified personnel, taking into account the requirements of employers, with the aim of acquiring education seekers experience in the practical

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програмою підготовки педагога в університеті і актуальними вимогами шкільної практики та підвищити показники якості підготовки кваліфікованих кадрів з урахуванням вимог роботодавців з метою набуття здобувачами освіти досвіду практичного застосування практичних навичок та їх соціальної і професійної адаптації до умов реальної практичної діяльності можна, на нашу думку, шляхом впровадження дуальної форми здобуття освіти. Вирішення проблеми передбачається шляхом реалізації комплексу заходів з модернізації структури, змісту, технологій та методик підготовки вчителів математики, в тому числі розробки та впровадження моделей взаємовигідного партнерства між закладами вищої освіти, роботодавцями та здобувачами освіти, спрямованих на підвищення ефективності практичної підготовки майбутніх учителів до практичного застосування набутих знань і вмінь, їх соціальну та професійну адаптацію в умовах реальної професійної діяльності.

Висновки. Ми усвідомлюємо, що дуальна форма освіти - не єдиний спосіб подолання кризи підготовки вчителів математики в Україні. Однак, на нашу думку, саме ця форма дозволяє гармонійно поєднати теоретичну і практичну підготовку майбутнього педагога, сприятиме налагодженню механізмів тісної взаємодії закладів вищої освіти, які готують вчителів, із закладами загальної середньої освіти для врахування потреб шкіл і вимог роботодавців до фахової підготовки вчителя. Введення дуальної форми здобуття освіти допоможе змінити ставлення до власної професії в середовищі самих учителів, оскільки процес передавання досвіду від вчителя-наставника до студента забезпечує усвідомлення необхідності власної професії як для всього суспільства, так і для наступних поколінь вчителів.

КЛЮЧОВІ СЛОВА: дуальна форма здобуття освіти; якість освіти; професійна підготовка вчителів математики.

application of practical skills and their social and professional adaptation to the conditions of real practical activity is possible, in our opinion, by introducing a dual form of education. Solving the problem is envisaged through the implementation of a set of measures to modernize the structure, content, technologies and methods of training mathematics teachers, including the development and implementation of mutually beneficial partnership models between higher education institutions, employers and students, aimed at increasing the effectiveness of practical training of future teachers for the practical application of acquired knowledge and skills, their social and professional adaptation in the conditions of real professional activity.

Conclusions. We are aware that the dual form of education is not the only way to overcome the crisis of mathematics teacher training in Ukraine. However, in our opinion, it is this form that allows to harmoniously combine the theoretical and practical training of the future teacher, will contribute to the establishment of mechanisms of close interaction between institutions of higher education that prepare teachers and institutions of general secondary education to take into account the needs of schools and the requirements of employers for professional teacher training. The introduction of a dual form of education will help to change the attitude towards one's own profession among teachers themselves, since the process of passing on experience from a teacher-mentor to a student ensures awareness of the necessity of one's own profession both for the entire society and for the next generations of teachers.

KEYWORDS: dual form of education; quality of education; professional training of mathematics teachers.

INTRODUCTION

Formulation of the problem. Analysis of current research. The theory of *complex systems* is currently in a period of rapid development and has gained popularity in the world. As stated in (Bar-Yam, 2002), a complex system is a system consisting of many components that can interact with each other. Examples of complex systems are the Earth's global climate, organisms, the human brain, infrastructure such as energy systems, transportation or communication systems, social and economic organizations, ecosystems, living cells, etc. Complex systems are systems whose behavior is difficult to model in traditional ways, they have special properties, including, in particular, nonlinearity, heterogeneity, and spontaneity. Obviously, such systems can include both education in general and methods of its organization in any specific country, in particular, in Ukraine.

Qualitative training of teachers, in particular, teachers of mathematics, has always been and is the primary task of a pedagogical university. This goal is determined both by the demands of modern Ukrainian society (see, for example, (EdCamp, 2019) and (MES of Ukraine, 2022)), and by state documents regulating the activities of Ukrainian higher education institutions (Verhovna Rada, 2014; Verhovna Rada, 2017). The problem of ensuring the proper quality of professional training of mathematics teachers becomes particularly relevant in the context of the implementation of the New Ukrainian School project (NUS, 2019), which involves significant changes in methodological approaches to education. The implementation of these changes rests, first of all, on the teaching community, and therefore on the new generation of teachers who have just graduated from the university and are gaining their first experience at school.

According to the Law of Ukraine "On Higher Education", "the first (bachelor's) level of higher education provides for the acquisition of higher education graduates the ability to solve complex specialized tasks in a certain field of professional activity" (Verhovna Rada, 2014). The professional standard for the profession "Teacher of a general secondary education institution" (MES of Ukraine, 2020) stipulates that a bachelor's degree graduate can obtain the qualification of a teacher of a general secondary education institution. However, this training is only basic. Acquiring by students of higher education the ability to solve problems of a research and/or innovative nature in a certain field of professional activity requires the second (master's) level of higher education. Therefore, in our opinion, it is the training of masters in pedagogical universities that deserves special attention.

Currently, in the National Pedagogical Dragomanov University and other pedagogical universities of Ukraine, the training of masters in the specialty 014 Secondary Education (Mathematics) takes place in a traditional way, which involves lectures, practical, laboratory and seminar classes, as well as practice at school. A similar system has been tested for decades and under conditions of proper implementation provided good results. However, we should admit that in modern conditions, the traditional system of master's education is somewhat outdated and needs to be modernized.

Indeed, in conditions where the popularity of the teaching profession is declining, and the number of graduates of physical and mathematical faculties of pedagogical universities is constantly decreasing (Repko & Ruda, 2017; Perekrst, 2018; Censor.net, 2018), schools (especially in large cities of Ukraine) feel an urgent need for mathematics teachers. So, for example, according to information from the employment department of the National Pedagogical Dragomanov University, as of November 5, 2021, there were 342 vacancies for mathematics teachers in Kyiv, and 206 vacancies in the Kyiv region (NPDU, 2021). Thus, a significant part of master's students who already have a higher education and can work at the school actually work there. According to the statistics of the Dean Office of the Faculty of Mathematics, Informatics and Physics of the NPDU, every year from 35 to 50 percent of full-time master's students (!) combine study with work in Kyiv schools and are forced to study according to an individual schedule. So, for example, in 2021, 16 out of 29 master's students in mathematics worked at school as mathematics teachers. Among 45 mathematics students of the 4th year of bachelor's degree, 10 combined study with work at school.

As a result of the above circumstances, the traditional scheme of master's training cannot be adequately provided, because a significant part of students does not attend the required number of lectures and practical classes, and practice at school, in fact, is reduced to "attending" it at the workplace. In fact, instead of the teacher, fellow students, and the supervisor

from the university, only the latter is present at the lessons held by the master during the training practice. This significantly reduces the quality of the discussion of the classes, which, moreover, are often no longer training classes, but real lessons, in which methodological errors are not very desirable. So, the responsibility of the intern student increases, for which not all future masters are psychologically ready.

The given facts indicate the presence of *inconsistencies and contradictions* between:

- state requirements for the quality of training of mathematics teachers and the current state of ensuring this quality;
- the school's needs for qualified teachers of mathematics and the real possibilities of pedagogical universities to realize this need;
- the needs of pedagogical universities regarding qualitative practical training of future teachers of mathematics and the real state of the possibility of providing this training during educational practice at school;
- the need to adapt young teachers of mathematics to the specifics of school work and the insufficient opportunity to accomplish this adaptation during students' educational practice.

In modern conditions, the *main problem* of master's training of mathematics teachers is the discrepancy between the real quality of practical training of graduates of pedagogical universities and the existing requirements and demands of society (administrations of educational institutions, parent and student communities) to the level of teacher training.

This problem has a number of negative manifestations and consequences, the most negative of which are, on the one hand, the unpreparedness and reluctance of graduates of pedagogical universities to work in their profession, and on the other hand, dissatisfaction with the labor market, both quantitatively (a large number of unfilled vacancies for mathematics teachers), and qualitative aspects (insufficient level of competence of some specialists). At the same time, it is important to overcome the imbalance between the public demand for highly qualified teachers and the opportunities to organize their preparation in the conditions that have developed, as well as between the high-quality educational process and, accordingly, the real level of readiness of the majority of graduates of pedagogical universities for independent professional activity based on the obtained qualifications.

So, the problem has a complex nature. One of the effective ways to solve this problem, according to the authors opinion, is the creation of an effective system of qualitative combination of theoretical and practical training of future teachers with professional activities even during their studies at the university.

RESEARCH METHODS

To achieve the goal of the work, we use the theoretical method of analyzing methodological literature on the researched problem. We also use some empirical methods: surveying students about their employment, observing the educational process of teacher training in pedagogical universities, analyzing the educational achievements of future mathematics teachers in the field of their theoretical and practical training. In this article, we also use a set of methods of scientific knowledge: comparative analysis to clarify different views on the problem; systematization and generalization in order to draw conclusions and formulate recommendations regarding directions for improving the methodology of training future mathematics teachers; summarizing the pedagogical experience and observations of the authors.

RESULTS OF RESEARCH

To eliminate the main shortcomings of the traditional forms and methods of training future specialists, to overcome the gap between the teacher training program at the university and the current requirements of school practice, and to increase the quality indicators of the training of qualified personnel, taking into account the requirements of employers, with the aim of acquiring education seekers experience in the practical application of practical skills and their social and professional adaptation to the conditions of real practical activity is possible, in our opinion, by introducing a *dual form of education*.

Solving the problem is envisaged through the implementation of a set of activities to modernize the structure, content, technologies and methods of training mathematics teachers, including the development and implementation of mutually beneficial partnership models between higher education institutions (pedagogical universities), employers (schools) and students, aimed at increasing efficiency practical training of future teachers for the practical application of acquired knowledge and skills, their social and professional adaptation in the conditions of real professional activity.

The dual form of higher education is a method of obtaining education by full-time students, which involves training at the workplace at enterprises, institutions and organizations to acquire a certain qualification in the amount of 25 percent to 60 percent of the total amount of the educational program based on the contract. On-the-job training involves the performance of job duties in accordance with the employment contract (Verhovna Rada, 2014, chapter 49, part 6).

The homeland of dual education is rightly considered to be Germany, which standardized the training of specialists in vocational education institutions in close cooperation with enterprises as early as the 60s of the 20th century. At the same time, the training model "apprentice - assistant - master" was created by the first craft guilds in the cities of the development of trade in Germany as early as the 12th century, compulsory vocational education for workers was introduced in 1869, and in 1897 the Law on the Protection of Craftsmen - for the first time provided and regulated principle of dual vocational training. The Law on Vocational Training of 1967 standardized the norms, which previously differed depending on the region, and also provided for the participation and close cooperation of social partners in all matters of vocational training. This approach was later adopted in Europe, South Korea, China, and Canada. Today, 50% of people receiving education study in the dual education system of Germany, Austria, and Switzerland. In South Korea and China, it covers 33% of those who receive an education (Drozach, 2008).

In Ukraine, at the moment, there is an increased interest in the implementation of elements of dual education system. The first steps of the implementation of dual education in Ukraine were initiated in 2013 with the joint project of the representative office of the Friedrich Ebert Foundation in Ukraine, the Marketing Association and Sumy State University "Implementation of elements of the dual education system in higher education institutions of Ukraine to increase the competitiveness of graduates on the labor market". In 2014, with the support of MES of Ukraine, 14 pilot micro-projects for the

implementation of dual education in higher education institutions were organized, the Roadmap for the implementation of dual education in Ukraine (MES of Ukraine, 2017) was developed, and based on the results of the implementation of the four-year project, work began on the creation of the Concept of dual-form training of specialists obtaining an education (Cabinet of Minister of Ukraine, 2018). The working group included representatives of higher education institutions, scientific institutions, and the Federation of Employers of Ukraine. Developed and approved by the Cabinet of Ministers of Ukraine in 2018 the Concept is based on the German experience of dual education.

In October 2019, a pilot project was launched in institutions of vocational pre-higher and higher education on training according to the dual form of obtaining education, designed for 2019-2023. Since 2019, 27 institutions of higher education, 17 institutions of professional preliminary higher education, and 198 partner enterprises have become participants in the project. In 2021, another 40 institutions of higher education, 13 institutions of professional preliminary higher education, and 381 partner enterprises joined the project. As a part of the project were developed and approved the Regulation on the dual form of professional (vocational and technical) education (Cabinet of Minister of Ukraine, 2019) and the Draft of Regulation on the dual form of education in institutions of higher and professional pre-higher education.

Pedagogical universities were not involved in the MES of Ukraine experiment. Presumably, the reason is that Germany, whose experience was primarily taken as a basis in Ukraine, does not have the practice of training teachers according to the dual form of education. However, it is worth noting that our own position regarding the perspective of teaching teachers using a dual form of education is shared by our colleagues from the University of Bielefeld (Germany). At the same time, the Concept of the Development of Pedagogical Education (MES of Ukraine, 2018) provides for the possibility of training teachers using a dual form of education.

Despite the presence of a significant number of publications devoted to various aspects of the training of mathematics teachers and the features of the dual form of education (Abashkina, 1998; Boychivska, 2013; Falyakhov, 2018; Oleksin & Yakubovska, 2018; Schelten, 2001; Stratmann & Schlosser, 1990; Stegmann 1986; Turner, 1993; Zembytska, 2016; etc.), the problem of introducing a dual form of education into the mathematics teacher training system in Ukraine was not systematically considered. In addition, we note that even in Germany, which is a pioneer of dual education, the dual form of obtaining education was not considered as potentially possible in the training of teachers and, as already mentioned above, at the moment German researchers are interested in joint development of this topic with the authors of this article.

Thus, a comprehensive study aimed at the development of the theoretical-methodical and organizational-pedagogical foundations of the introduction of professional training of future mathematics teachers according to the dual form of education in higher education institutions of Ukraine is relevant, which includes: the development and justification of the concept of dual form of education by future teachers of mathematics; development of documents regulating the goals, content and main results of teacher training; creation and approval of methodological recommendations for the implementation of a dual form of teacher training for higher education institutions and schools; implementation of the system of training mentors and practice managers of dual-educators. The introduction of a dual form of education for mathematics teachers should be based on fundamental research on the theory of learning, as well as implement the main didactic principles of this theory, take into account the features of the modern information society in accordance with the main directions of the development of innovative activity.

To realize this goal, the following *main tasks* have to be performed.

1. To develop a conceptual model of dual education of future teachers of mathematics at the master's level of education.
2. To determine the model, methodology and mechanisms of implementation of the innovative interaction "school-pedagogical university" (Matiash et. al., 2021) for effective coordination between the institution of higher education, local authorities and employers in terms of the content of education and practical training of students.
3. To develop a schedule for the organization of the educational process according to the dual form of education in the preparation of teachers of mathematics.
4. Prepare a description of the technology for developing an educational plan and programs for teacher training based on a dual form of education.
5. To develop training plans for teachers of mathematics according to the dual form of education.
6. To implement dual education in the system of training teachers of mathematics.
7. To develop instructional materials for schools and methodological recommendations for teacher-mentors (mentors) and practice managers from the university regarding the organization of the practical part of teacher training for mathematics according to the dual form of education.
8. Develop a program for training certified mentors.
9. To develop instructional materials and methodical recommendations for higher education institutions regarding the training of teachers of mathematics on a dual form of acquisition (master's level).
10. To develop methodological recommendations: regarding the application of innovative technologies in the conditions of a dual form of education, in particular the technology of mixed learning, regarding the teaching of certain disciplines and regarding the organization of research work.

Research within the framework of the scientific project "Dual form of education and blended learning in the mathematics teacher training system" was started at the National Pedagogical Dragomanov University (Kyiv, Ukraine) in 2021. The following research *results are expected*.

1. Results of monitoring the state of the problem of training and employment of mathematics teachers from the point of view of employers (schools), students (students) and higher education institutions.
2. Conceptual model of dual education of future mathematics teachers at the master's level of higher education, in particular:
 - 2.1. Organizational forms of university-based education in the conditions of a dual form of education.
 - 2.2. Organizational forms of education on the basis of a secondary education institution in the conditions of a dual form of education.

- 2.3. Methods, means, technologies of training of mathematics teachers according to the dual form of education.
3. The model and mechanisms of implementation of the innovative interaction "school-pedagogical university" for effective coordination between the institution of higher education, local authorities and employers in terms of the content of education and practical training of students.
4. Schedule of the organization of the educational process according to the dual form of education in the preparation of mathematics teachers.
5. Description of the technology for developing an educational program for training mathematics teachers according to the dual form of education.
6. Educational plan for the training of mathematics teachers according to the dual form of education (master's level).
7. Implementation of the system of training mathematics teachers according to the dual form of obtaining education (master's level).
8. Methodological recommendations regarding the organization of the practical part of mathematics teacher training:
 - 8.1. Methodical recommendations for teachers-mentors.
 - 8.2. Methodical recommendations for practice managers from the university.
9. Methodological recommendations for the training of future teachers of mathematics according to the dual form of education, in particular:
 - 9.1. Methodological recommendations for teaching individual disciplines.
 - 9.2. Methodological recommendations on the application of innovative learning technologies, in particular mixed learning technologies and ICT technologies.
 - 9.3. Methodological recommendations on the organization of scientific research work of students.
10. Instructional materials for schools regarding the organization of the practical part of mathematics teacher training.
11. Instructional materials for institutions of higher education regarding the training of mathematics teachers by the dual form of acquisition (master's level).
12. Training program for certified mentors.
13. Results of monitoring the implementation of the dual form of education in the training of mathematics teachers.

CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

The introduction of a dual form of education will allow to increase the amount and change the nature of the practical training of future mathematics teachers, to give the school already adapted to the school team, working conditions and a professionally motivated specialist who will work in the chosen specialty for a long time and at the appropriate level of quality in the future. In particular, this will partially solve the problem of staff shortages in schools in big cities. During the year of practical work at the school, the young specialist will fully adapt to the working conditions and become a full-fledged member of the teaching team. His (her) fear of children will disappear, he (she) will fully understand the specifics of work and problems, and, at the same time, he (she) will know that he can always turn to a mentor-mentor for advice. All this will avoid difficulties at the initial stage of work after graduating from university. As a result, the graduate will remain working at the school.

Employers will have the opportunity to influence the process of training (and later, upgrading) a specialist with the necessary knowledge, skills and competences, to receive qualified personnel who are trained according to their requirements, familiar with the features (profile, specialization, etc.) of the school, pedagogical and student team and do not require additional training and adaptation, as well as the opportunity to select the most talented students for an invitation to work after graduation. The introduction of the institute of mentoring will contribute to the formation of an atmosphere of mutual assistance and mutual responsibility in the institution of secondary education, and will also allow preserving the continuity of generations and positive educational practices. A teacher-mentor in this system improves his (her) own qualifications by teaching students, as well as receives additional earn for accomplishing the duties of a mentor. At the same time, there will be an opportunity to develop a system for forecasting personnel needs.

Pedagogical universities will have access to up-to-date information on the requirements of employers for future teachers, will have a deeper understanding of the real needs and conditions of schools, which will make it possible to quickly update the content and methods (technologies) of training future teachers. For the university, closer cooperation with the institution of general secondary education under conditions of mutual trust will open up a new opportunity - not only to participate in the training of young professionals, but also to fully control the entire process of the teacher's professional growth (training, advanced training, constant support and cooperation). As a result, all this will contribute to increasing the competitiveness of the university in the market of educational services. In addition, the university will receive a highly motivated student (knowledge becomes in demand).

We are aware that the dual form of education is not the only way to overcome the crisis of mathematics teacher training in Ukraine. However, in our opinion, it is this form that allows to harmoniously combine the theoretical and practical training of the future teacher, will contribute to his professional growth and faster social and professional adaptation to the conditions of work at school, will contribute to the establishment of mechanisms of close interaction between institutions of higher education that train teachers and institutions of general secondary education to take into account the needs of schools and the requirements of employers for professional teacher training, and in the end should become an effective tool for solving a wide range of problems of modern Ukrainian society.

The introduction of a dual form of education will help to change the attitude towards one's own profession among the teachers themselves, since the process of passing on experience from the teacher-mentor to the student ensures the teacher's awareness of the necessity of one's own profession both for the whole society and for the next generations of teachers. The dual form of education, in contrast to the traditional practice at school, will make it possible to bring to school not a temporary observer of the educational process, but an active participant in it, as well as solve the problem of a shortage of teaching staff, which is especially relevant for large cities.

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